Math Circles Inscribed in Ohio

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The purpose of this article is to describe the preparation and implementation of a mathematics circle in Northeastern Ohio. Math Circles encourage the enjoyment, appreciation and knowledge of mathematics through problem solving and guided discovery. Also documented is the close collaboration teachers, students, and university personnel share. All aspects of the program are discussed with references to Russian Math Circles. While the Math Circle's goal is to develop reasoning and problem solving skills, students come to enjoy, appreciate, and expand their knowledge of mathematics.

Introduction

"Math circles are weekly math programs that attract middle and high school students to mathematics by exposing them to intriguing and intellectually stimulating topics. [The goal is] . . . to inspire in students an understanding of and a lifelong love for mathematics" (Stankova and Rika, 2008, p. ix).

This article describes how a Math Circle began in Ohio in the hopes that this information may be helpful to those considering implementing such a program. Our inspiration to start a math circle came from Dr. Jenya Soprunova, a faculty member at Kent State University. She had fond memories of participating in math circles as a child in Moscow and hoped to start a math circle locally. Throughout Dr. Soprunova's course, she utilized techniques and problems found in math circles. We thoroughly enjoyed these classes and were eager to implement what we had learned with our own students. In fact, most of the topics we covered in the math circle were topics we had covered in our graduate level mathematics for teaching courses.

A Locus of Logistical Points

The planning of the Math Circle began in October 2010. There were many organizational details and questions we had to answer before meeting with students. These issues included: How do we recruit students for our Math Circle? Where, how long, and how often will we meet? What liability concerns are there for meeting with students beyond regular school hours? How can we create a way for the student to communicate about the Math Circle easily with us and with one another? What will we need to do keep students motivated to participate and to challenge themselves? And finally, how will the meetings be organized?

Recruitment of students was probably the easiest for us to answer. When this opportunity came about, we all immediately had in mind several students from our classes that had shown advanced thinking and/or a high level of interest in mathematics beyond the classroom. Some examples of qualities these students possessed were: the ability to solve Rubik's cube, strong interest in "Challenge Problems" we gave our students on a weekly basis, high levels of questioning during lessons and advanced placement in mathematics courses. Ultimately, the majority of the student math circle participants were personally asked to participate in the math circle. These students, in turn, invited others who they believed would be interested in problem solving.

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In the end, twenty students attended math circle meetings. Most students attended meetings consistently and only had to occasionally miss a meeting for another event. These students represented all grade levels, from Geometry to AP

Calculus students. Because of this variety, we had to make sure that any topic discussed at the math circle meetings was accessible to all students but still a challenge for everyone. We also had to provide background information needed to complete the problems.

When deciding where, when, and how often to meet, we encountered a few obstacles. First, we teach at two high schools that are approximately 45 minutes apart, so we had to decide on a common meeting place. We met at the Kent State--Stark Campus. With some help, a room was reserved for our meetings and parking passes were created for our students and us. Second, after speaking with students we knew would participate, we realized we would have to schedule our meetings around other commitments they already had - including sporting events, play practices, ACT review courses, and other activities. After considering all of these scheduling conflicts, we decided to meet twice a month on Wednesdays from 5:00 pm to 7:00 pm so that the maximum number of students could attend all of the meetings. Our meetings began in late November 2010 and lasted through April 2011.

After each meeting, three to six challenge problems were posted on the website and assigned to the students to work on before the next meeting. They were allowed to work both individually and with others.

As teachers, we also had to make sure we were covered to meet with these students outside of school hours, from a liability standpoint. Most importantly, we wanted to make sure parents were fully aware of the group's objectives, meeting times, and commitment requirement. All students and their parents filled out a permission slip for the math circle. We also had each parent fill out an emergency medical form in case we needed to contact them during a meeting for any reason.

Another issue that arose from the distance between schools was how we would be able to allow students to communicate about the math circle easily with us and with one another in between meetings. To solve this problem, we created a website link and blog that would allow us to post meeting information, problems, and allow for student interaction. Unfortunately, while most students utilized the website often, the blog was not successful. When we asked the students why this was, the two most common responses were that it was not useful due to little activity on the site and that they did not want to look at others' work because they wanted to figure the problems out on their own.

A Locus of Problems

When Dr. Soprunova explained her math circle experience in Moscow, she described a point system that was implemented to motivate students to complete challenging problems. There, students were given challenge problems to complete in groups or on their own that went with the current topic being discussed (Vandervelde, 2009). After a student found a solution, they presented it individually to the person running the meetings to earn points. Point values varied based on the difficulty level of the problem (see also http://www.mathcircles.org).

We decided to implement this system in our math circle. After each meeting, three to six challenge problems were posted on the website and assigned to the students to work on before the next meeting. They were allowed to work both individually and with others. Then, for the first half hour of our meetings while students socialized and had a snack, we sat down with individual students, and they presented their solutions to us. We had a wide range of outcomes from our challenge problems. Some students found solutions to almost every challenge problem and spent several hours a week working on the problems, while others only worked on the challenge problems during the half hour before meetings and found few solutions. Although the dedication levels varied, we

were excited to see that all of the students were interested in working on the challenge problems and were especially eager to hear and present solutions at the beginning of each meeting (Fomin, D., Genkin, S., and Itenberg, I. 1996).

After the challenge problems had been presented, a new topic was introduced at each meeting. These topics included: Logic, Coins, Parity, Chessboards and Tiling, Divisibility, Games, Modular Arithmetic, Magic Squares, and the Triangle Inequality Theorem (See Figure 1). For our final meeting we decided to have a culminating final tournament where students could utilize information they learned throughout the weeks. To make this last meeting more celebratory and enjoyable for the students, we also had a pizza party, prizes for top challenge problems points prizes for tournaments, and certificates of participation for all students.

1. Find the last digit of the number 2^{50}.
2. Jack tore out several successive pages from a book. The number of the first page he tore out was 183, and it is known that the number of the last page is written with the same digits in some order. How many pages did Jack tear out of the book?
3. Mrs. Claus needs to get 4 gallons of water for the reindeer to drink during their Christmas Eve trip. She has a 5-gallon jug and 3-gallon jug, and an unlimited access to water, how can she measure exactly 4 gallons of water?
4. Two children take turns breaking up a rectangular candy that is 6 squares wide by 8 squares long. They may break the bar only along the divisions between the squares. If the bar breaks into several pieces they keep breaking the pieces up until only one individual square remains. The player who cannot make a break loses the game. Who will win?
5. Solve for *x* and *y*:
$(3 - x - y)^2 + (x - 2y)^2 = 0$

Fig 1 Sample Tasks

Reflection

Looking back on the past few months of our work with the math circle, we have many thoughts about how things ultimately went and how to improve upon the experience. Overall, we were incredibly pleased with the outcome.

First, we were happy to see the high level of dedication that all students had towards the math circle. Many students had to travel more than a half hour one way for each meeting. Most students attended all sessions and when they did miss a meeting it was due to a scheduling conflict, not lack of interest. During the meeting, students actively participated and solved the problems enthusiastically. Many of these problems were accessible to all students no matter the level.

It was evident there was a nice balance between a camaraderie to solve the problems together and the desire to fully understand the problems individually. In fact, students often showed their competitive sides while attempting to earn points for challenge problems and as they competed against one another in the final competition. Our University advisor conducted one meeting. What the students received from her presentation was enlightening to them not just from a content point of view but also as a valuable window into the college experience.

The most encouraging feedback we received from the students was that as a group, they had a good experience in the math circle. All the students answered that they would either absolutely or most likely continue with a math circle and would encourage their friends to do the same.

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Minor Changes

We did not assign groups, but on the occasion that we did assign them into heterogeneous groups, the students worked

well together. In the future, we will make an intentional effort to place them with a variety of individuals when solving problems. Finally, although we had access to white boards and projectors at all of the meetings, it would have been nice to also have SMART Board software available to us. This technology would have allowed us to capture and save more student work that was presented during the meetings.

In spite of these minor disappointments, we were thankful for the opportunity to implement a math circle with such exceptional students and hope to continue such a project. Overall, we feel that every student walked away with a better understanding and better attitude towards mathematics.

References

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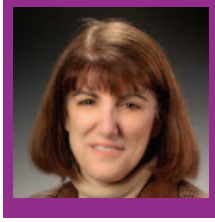

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